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NUMERICAL ANALYSIS AND MODELLING OF MICROSTRIP PATCH ANTENNAS WITH EMBEDDED DEFECTIVE GROUND STRUCTURE

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ABSTRACT

The key design issues of antennas at terahertz frequency applications is wide bandwidth, there is a necessity to numerically analyze the electrical and physical parameters of the antenna structures. Simultaneously electro-geometrical modelling of the antennas with Defective Ground Structures is a technological challenge towards the high frequency communication applications. Fundamentally this paper aims to analyze and discuss critically about the microstrip antenna structures with embedded W shaped defective ground structure. The conceptual in depth analysis of the DGS based antenna structures can lead to improve performance, realize the design and develop high bandwidth and directivity antennas which are potentially useful for the short range communication application of terahertz frequency.

KEYWORDS: Antennas, Bandwidth, Directivity, Defective Ground Antennas, Gain, Microstrip Patch Antennas, Return Loss, Terahertz Wireless Communications, Terahertz Antennas, VSWR

INTRODUCTION

The decade's progress in the field of antenna technology is highly appreciable in the field of science and technology [1]. The high bandwidth and directivity are the prime essential parameters demanded by the futuristic era of communication technology beyond 4th and 5th generation wireless communication system [2]. The Microstrip patch antennas have attracted various researchers to investigate on the applications at terahertz frequency due to its advantages [3][4] like low cost, less weight, compatibility, multiband and multi-frequency. In order to avoid path loss there is a requirement of high bandwidth and directivity for the successful functioning of wireless communication system [5][6]. The bandwidth can be increased by various methods; one of the best methods is by stacked patch technique [7] [8] in which the second patch is place in-front of the first one. The directivity can be increased by embedding defective ground structures in the antenna system.

In this present contribution the structures are designed using Polymide as substrate whose dielectric permittivity is 3.5. The electromagnetic coupling is used for feeding the second patch whereas the first patch is fed through a coaxial probe. The analysis of the radiating structures is done by varying the distance between the patches along with the rotation of patches and by embedding the W shaped defective ground structure.

ANTENNA STRUCTURE

The figure 1 shows the proposed design of conventional patch antenna and figure 2 shows the proposed design of the stacked patch model. In proposed model of antennas patch is printed on a ground plane with polymide as a substrate of thickness't'. The upper patch is placed at a distance'd' above the lower patch.

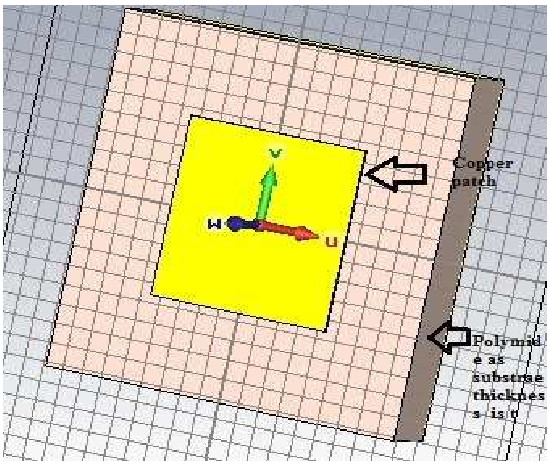

Figure 1: Conventional Patch Antenna

The width [5] of the patch can be calculated using the equation (1).

$$W = \frac{C}{2f_0}\sqrt{\frac{\varepsilon_r + 1}{2}} \tag{1}$$

Due to the fringing effect, the effective dielectric permittivity is to be considered.[5] The effective dielectric permittivity can be calculated using equation (2)

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[\frac{1}{\sqrt{1+12(h/W)}}\right] \tag{2}$$

The length [5] of the patch can be calculated using the equation (3).

$$L = \frac{C}{2f_0\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{W}{h}+0.8)}\right) \tag{3}$$

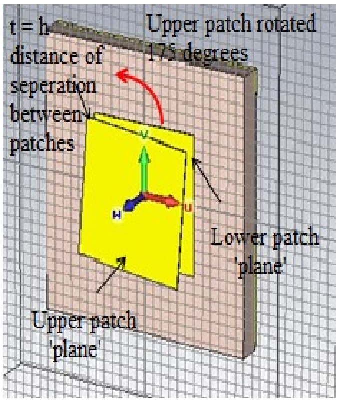

Figure 2: Proposed Model of Stacked Patch Antenna with Distance Variation And Rotation of Upper Patch At 1750

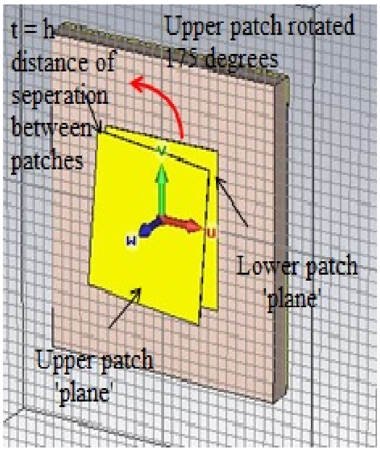

Figure 3: Front View of Stacked Patch DGS Antenna for the Configuration Case B Both Plane with Distance of Separation between Patches $t = \mathrm{h}$, Along With Angular Rotation of 175^0 and U_{13}Configuration of DGS

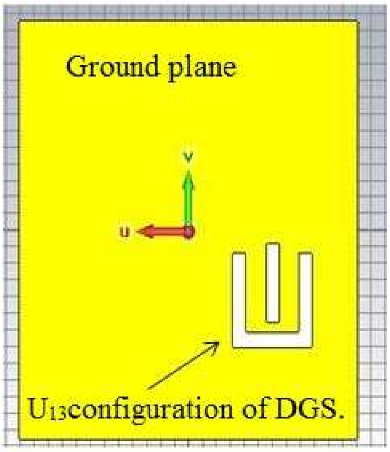

Figure 4: Back View of Stacked Patch DGS antenna for the Configuration Case B Both Plane with Distance of Separation between Patches $t = \mathrm{h}$, Along with Angular Rotation of 175^0 and U_{13}Configuration of DGS

Table 1: Design Parameters of the Proposed Model

Sr. No	Parameter	Polymide
1.	Dielectric Permittivity of Substrate (Ɛr)	3.5
2.	Thickness of the lower patch	1 µm
3.	Thickness of the upper patch	1 µm
4	Distance of separation between the patches	d µm
5.	Length of the patch	130 µm
6.	Width of the patch	146 µm
7.	Resonant frequency	0.6THz

RESULTS AND ANALYSIS

The design and analysis is carried out in CST Microwave studio which uses the finest integral technique.

Case 1: Conventional Patch Model

Return Loss

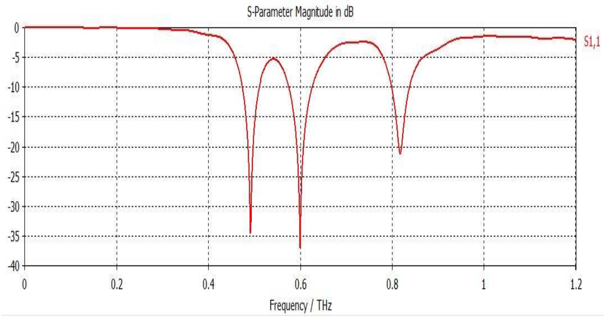

Figure 5: Return Loss Plot of Case 1 Conventional Patch of Proposed Model Using Polymide as Substrate

Gain

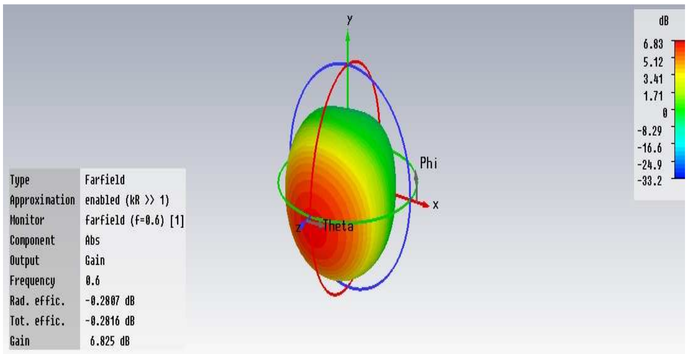

Figure 6: Gain Plot of Case 1 Conventional Patch of Proposed Model Using Polymide as Substrate

Directivity

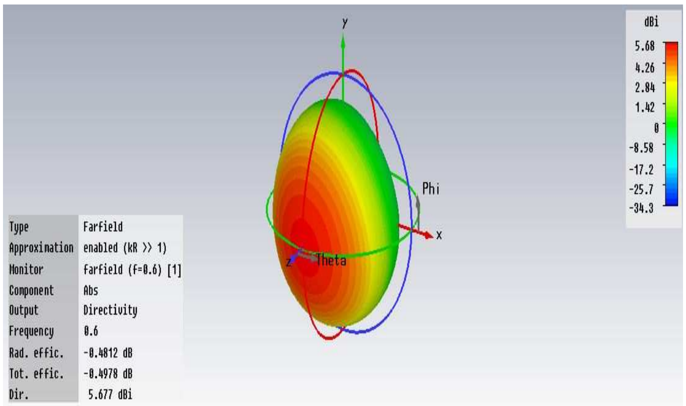

Figure 7: Directivity Plot for Conventional Patch Antenna Using Arlon Substrate Modeled In CST

VSWR

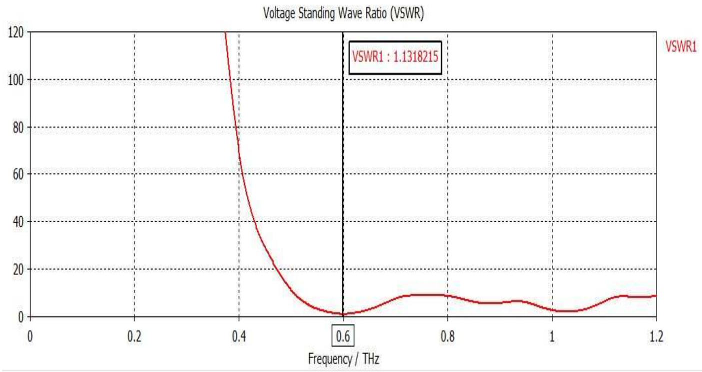

Figure 8: VSWR Plot for Conventional Patch Antenna Using Arlon Substrate Modeled in CST

Case 2: Stacked Patch Antenna

Return Loss

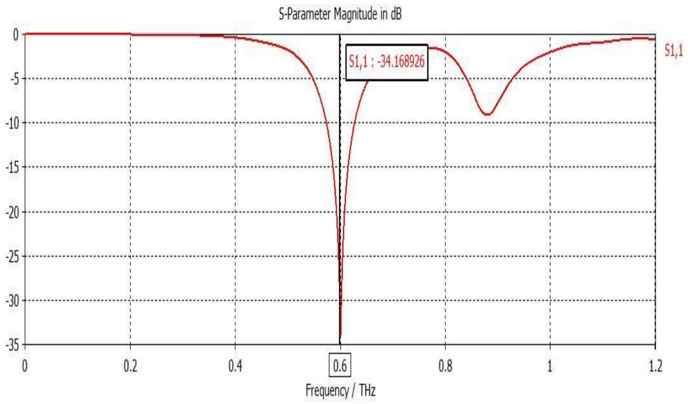

Figure 9: S_{11} Plot of Stacked Patch Antenna for the Configuration Both Plane with Distance Variation $t = h$ and 175^0 Rotation of Top Patch Using Polymide as Substrate

Gain

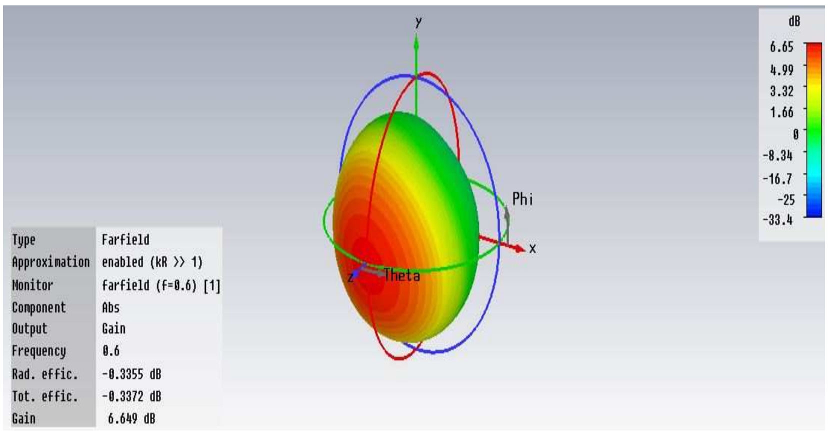

Figure 10: Gain Plot of Stacked Patch Antenna for the Configuration Both Plane with Distance Variation $t = h$ and 175^0 Rotation of Top Patch Using Polymide as Substrate

Directivity

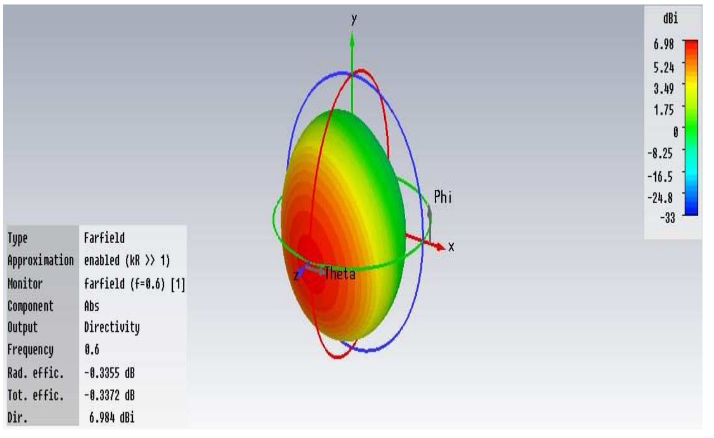

Figure 11: Directivity Plot of Stacked Patch Antenna for the Configuration Both Plane with Distance Variation $t = h$ and 175^0 Rotation of Top Patch Using Polymide as Substrate

VSWR

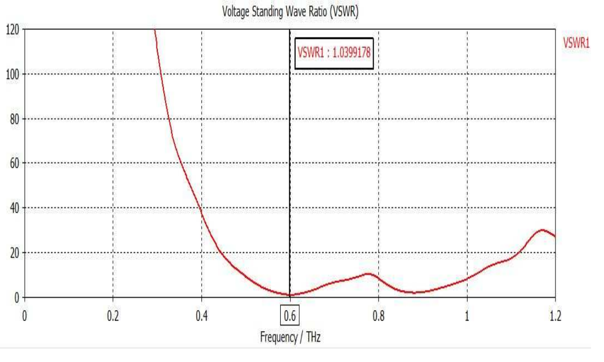

Figure 12: VSWR Plot of Stacked Patch Antenna for the Configuration Both Plane with Distance Variation $t = h$ and 175^0 Rotation of Top Patch Using Polymide as Substrate

Case 3: Stacked Patch Antenna with Defective Ground Structure

Return Loss

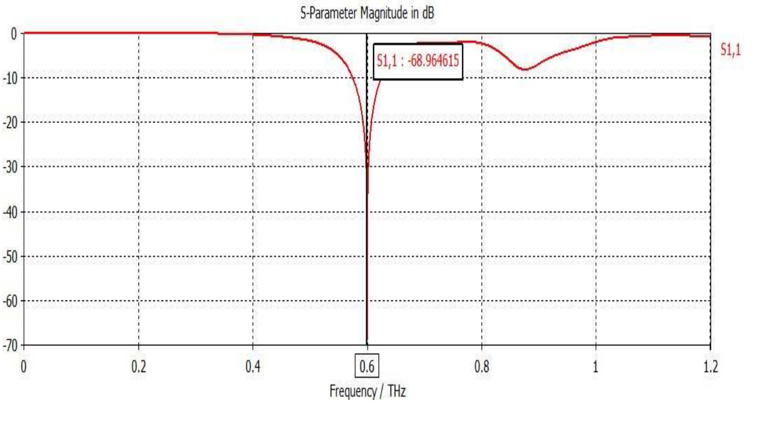

Figure 13: S_{11} plot of Stacked Patch DGS Antenna for the Configuration Case B Both Plane with Distance of Separation between Patches $t = h$, Along with Angular Rotation of 175^0 and U_{13}Configuration of DGS

Gain

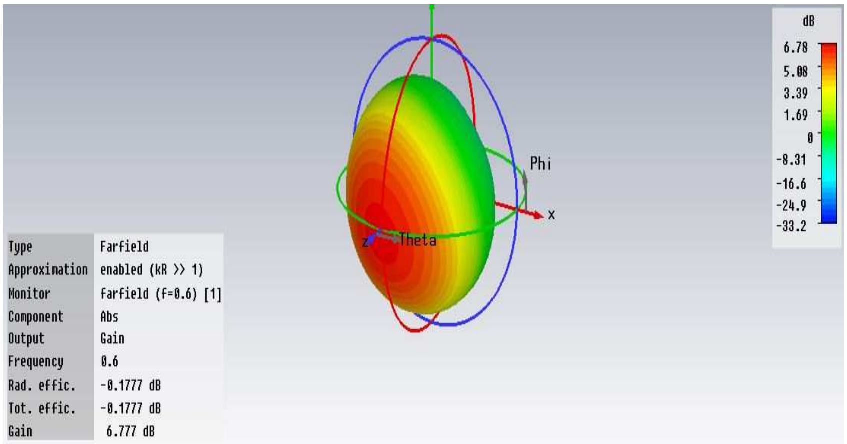

Figure 14: Gain Plot of Stacked Patch DGS Antenna for the Configuration for the Case B Both Plane with Distance of Separation between Patches $t = h$, Along with Angular Rotation of 175^0 and U_{13}Configuration of DGS

Directivity

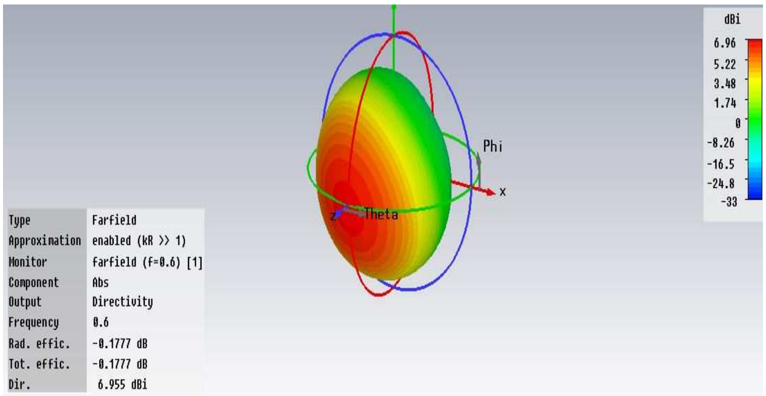

Figure 15: Directivity Plot of Stacked Patch DGS Antenna for the Configuration Case B Both Plane with Distance of Separation between Patches $t = h$, Along with Angular Rotation of 175^0 and U_{13}Configuration of DGS

VSWR

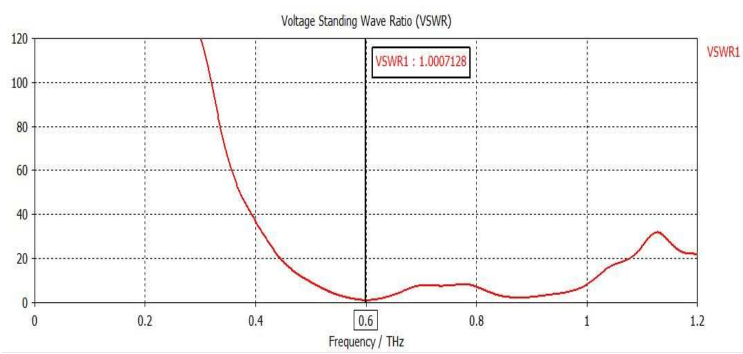

Figure 16: VSWR Plot of Stacked Patch DGS Antenna for the Configuration Case B Both Plane with Distance of Separation between Patches $t = h$, Along with Angular Rotation of 175^0 and U_{13}Configuration of DGS

Table 2: Comparison of Shortlisted Configurations of Stacked Patch DGS Antenna Modeled in CST

Configuration	Frequency (THz)	S11 (dB)	Gain (dB)	Directivity (dBi)	VSWR	Bandwidth (%)
Conventional Patch Antenna	0.49 0.6 0.8	-25.10 -36.39 -21.50	6.82	5.677	1.131	9.2
Stacked Patch Antenna Both plane $t = \mathrm{h}$, along with angular rotation of 175^0	0.6	-34.10	6.649	6.9556	1.039	8.5
Stacked patch antenna configuration Both plane $t = \mathrm{h}$, along with angular rotation of 175^0 and U_{13}configuration of DGS.	0.6	-68.96	6.777	6.984	1	9.1

Based on the results obtained as shown in figures 5 – figures 16 and table 2 the improvement in the S_{11} is mainly due to the shielding current distribution in the metallic ground will be disturbed due to the shape and geometry of the DGS which influences the impedance and current flow in the antenna. The effective capacitance and inductance will get changed due the shape and geometry of the DGS. The guided wave characteristics, band gap properties, bandwidth enhancements also influence due to the presence of the DGS in the ground plane. Highly directive antennas are essential at THz frequency range, in order to enhance the directivity of the antenna without compromising the bandwidth the new techniques are to be incorporated in the design and modelling of the patch antennas,

CONCLUSIONS

In this paper the conventional Microstrip patch antenna and stacked patch antenna with and without DGS are analyzed and simulated at Terahertz frequencies using Polymide as substrate. The mechanical distance of separation between patches along with the rotation of upper patch and embedding the W shaped Defective Ground structure to analyze this electromagnetic structure. These obtained electrical results after iterative simulations of the proposed model of antenna prove that the use of electromagnetic coupling enhances the value of reflection, gain and bandwidth when compared to those of a conventional patch antenna. The triple band resonance is obtained by carefully selecting the available substrate materials for the specified applications. At terahertz frequency the skin depth is also significant in determining the return loss, gain and bandwidth. The multiband multi frequency antennas and high gain antennas can be had by implementing the electromagnetic coupling technique. The proposed model has a wide scope in applications like high frequency radar sensing and wireless communications.

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